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RECONSTRUCTION OF A MOTORCYCLE HEAD-ON COLLISION - CZECH REPUBLIC CASE STUDY

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ABSTRACT

Traffic accidents represent significant obsession and concern for all members of society. They have become one of the most important problems that drain on manpower and material resources. In addition, it causes social and psychological problems for people with permanent disabilities caused by accidents. Thus, it becomes essential to find solutions and suggestions and put them into practice to reduce these accidents or at least address the causes and mitigate their negative effects.

One kind of these traffic accidents is a motorcycle one, preventing their serious injuries and deaths is a major and growing public health concern.

Motorcycling is enjoying an extraordinary boom in popularity. According to the "Report 2010" of the Association des Constructeurs Européens de Motorcycles (ACEM) (European motorcycle manufacturers' association), the number of motorcycles throughout the European Union rose from 16 million to more than 22 million between 2001 and 2008.

At the same time, motorcycles are by far the most dangerous means of transport. In 2008 the European accident database CARE (Community database on road accidents) recorded 5,126 fatalities amongst motorcyclists (EU-24), which is around 14% of the 37,234 fatalities in these 24 States [1].

This paper discusses mainly a reconstruction of a motorcycle head-on collision; where a solution of a specific accident will be shown – head-on collision of two motorcycles, which happened in Czech Republic. Also an overview of traffic statistics in Czech Republic is discussed as well; since there are no specific traffic statistics for motorcycle itself then general statistics will be shown.

KEYWORDS

Traffic, Czech Republic, PC Crash, Statistics

1 CZECH REPUBLIC AND ITS TRAFFIC STATISTICS

GENERAL INFORMATION OF CZECH REPUBLIC

Czech Republic borders Poland to the northeast, Germany to the west and northwest, Austria to the south and Slovakia to the east. This central European country has about 178.539 traffic crashes per year [2].

In 2009, there are 4,435.052 personal motor vehicles, 892.796 motorcycles, 607.412 lorries, 20.375 buses and 6,307.064 registered drivers in the Czech Republic.

Fig. 1 *Czech Republic Map*

Tab. 1 *Czech Republic general information*

Capital	Total area	Population (2009)	Registered cars (2009)
Prague	78,866 km^2	10,674,947	4,435,052

TRAFFIC STATISTICS OF CZECH REPUBLIC

Traffic accident statistics received considerable attention in order to be used to improve the traffic safety for reducing traffic accidents or at least decreasing their risks.

Traffic statistics is one of the important sciences that are used to reduce traffic accidents or decreasing at least their risks. The traffic accidents statistics is based on collection of traffic accidents information and perform a suitable analyze of them, some of these information are summarized as follows:

- Determination the circumstances or reasons caused the accidents (such as drunkenness, driving without a driver's license, the inefficiency of the vehicle, ... etc)
- Determination of most frequent types of traffic accidents in order to determine the reasons and trying to avoid their recurrence.
- Identification of categories, ages and nationalities of the perpetrators of the accidents.
- Determination the times of accidents (day, week, month, day / night).
- Determination of roads and sites of high frequency of accidents.
- Determination of economic cost of accidents.
- Evaluation of performance and productivity of the traffic policemen.

One kind of the traffic accidents is a motorcycle one, preventing their serious injuries and deaths is a major and growing public health concern.

In 2009, motorcycle caused a total of 1, 762 accidents in Czech Republic; some causes of motorcycle accidents can be described as follows:

- Lack of basic motorcycle riding skills.
- Failure to appreciate inherent operating characteristics.
- Failure to use safety precautions when riding.
- Inability to utilize defensive driving techniques.
- Lack of cornering or specific braking skills.
- Failure to follow reasonable speed.

General statistics of car accidents and violations in Czech Republic are illustrated in **Tab.2** and **Tab.3**

Tab. 2 *Traffic Accidents 2000-2009 in Czech Republic [3]*

Year	Number of accidents	Fatalities	Injuries
2000	211 516	1 336	32 588
2001	185 664	1 219	33 790
2002	190 718	1 314	34 505
2003	195 851	1 319	35 565
2004	196 484	1 215	34 421
2005	199 262	1 127	32 370
2006	187 965	956	28 221
2007	182 736	1 123	29 342
2008	160 376	992	28 585
2009	4 815	832	27 313

Tab. 3 *Traffic Rules Violations in the Czech Republic*

VIOLATION	PENALTY
Driving without a Valid License	25 000–50 000 CZK and imprisonment (1-2 years)
Seat Belts not fastened.	1500-2500 CZK
Dangerous or hasty Driving.	2500–5000 CZK and imprisonment (1–6 months)
Exceeding the prescribed Speed Limits.	Up to 5000 CZK and imprisonment (up to 60 months)
Driving under influence of Alcohol / Drugs.	10000–20000 CZK and imprisonment (6-12 months)
Using Mobile Phone while Driving.	1500–2500 CZK

2 A SOLUTION OF A REAL TRAFFIC ACCIDENT IN CZECH REPUBLIC

This part of the paper discusses a solution of a specific accident – head-on collision of two motorcycles- which happened in Czech Republic.

2.1 DISCOVERED FACTS

The discovered facts of this specific accident are described as follows:

- **REPORT ON ACCIDENT**

As it is written in the report on the accident, the accident of the CAGIVA Canyon 600 motorcycle (hereinafter Cagiva) and the HONDA SLR 650 motorcycle (hereinafter Honda) occurred in the urban area. Both participants were severely injured. The accident was supposed to happen so that the driver of the Cagiva motorcycle, while overtaking the Skoda vehicle, crossed over to the opposite direction, where he collided with the Honda motorcycle head-on.

The view was, at the point of collision, slightly decreasing in the direction of travel of the Cagiva motorcycle, the highroad was *6 m* wide. Road surface was dry and clean. At the time of examination of the place of accident by the police, it was clear, and visibility was not decreased by anything. Marks were documented at the place of accident.

As the starting point of measuring (hereinafter SPM) the police chose right corner of a building (corner house in the plan). The beginning of the blocking mark of the Cagiva motorcycle was situated *19,8 m* onwards from SPM and *2,4 m* left from the right edge of the road. This mark ended in probable point of collision (hereinafter PPC), which was situated *15,9 m* onwards from SPM and *2,9 m* left from the right edge of the road. At the PPC was also found a spilled liquid. At the PPC the frictional mark started, consisting also from mark of blue paint from the Cagiva motorcycle and ended under the Cagiva motorcycle, which was put on the right side with front wheel towards PPC. Centre of the front wheel of the Cagiva motorcycle was recorded *10,0 m* onwards from SPM and *6,7 m* from the right edge of the road. Centre of the rear wheel of the Cagiva motorcycle was situated *8,4 m* onwards from SPM and *7,4 m* left from the right edge of the road. In the grassy strip close to the Cagiva motorcycle *2,2 m* onwards from SPM and *7,0 m* left from the right edge of the road a rear-view mirror from the Cagiva motorcycle was found. The Honda motorcycle was put down on right side with its front part towards the middle of the road. Center of the front wheel was recorded at distance of *18,6 m* onwards from SPM and *2,3 m* left from the right edge of the road. Center of his rear wheel was at distance of *17,4 m* onwards from SPM and *1,4 m* left from the right edge of the road. On the road from PPC up to distance of *5,4* m from SPM there were (glass) fragments and plastic debris (fragments) recorded.

According to the report, damage to the Cagiva motorcycle related to both front directional lights, tank, seat, front fairing, headlight, dashboard, both mirrors, handlebars, handgrips, small lever of clutch, front fender, oil cooler, engine block on the left side, gearshift lever and crampons and other possible damage was not excluded. According to the report, damage to the Honda motorcycle related to directional front lights, headlight, front rim, front fender, front fork, dashboard, mirrors, front brake lever and other possible damage was not excluded as well.

❖ PLAN OF ACCIDENT SITE

The plan of accident site is in an acceptable accordance with the photo documentation and the report on accident.

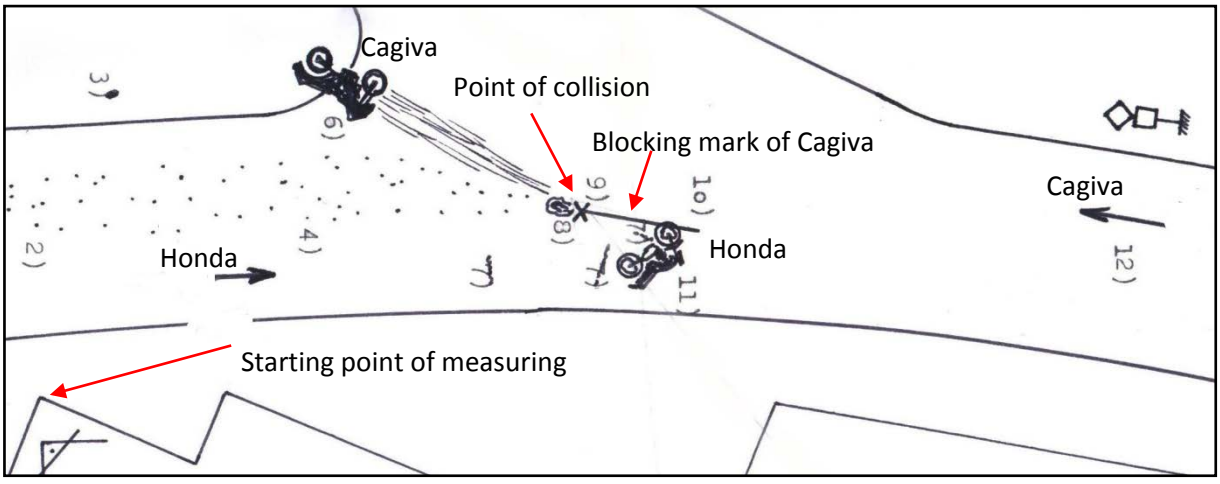

Fig. 2 *Plan of accident site - wheel locking mark of Cagiva from 10) to 9)*

❖ DOCUMENTATION PHOTOS

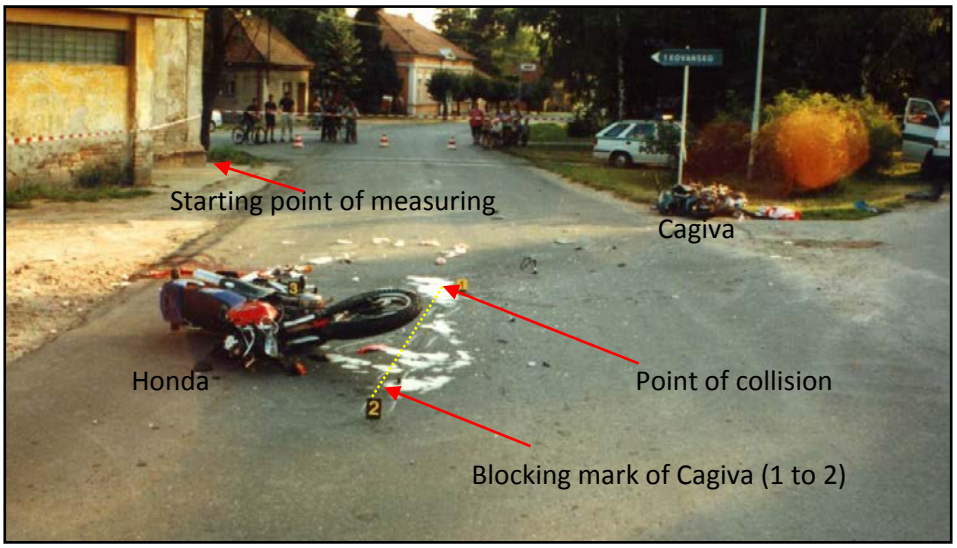

Fig. 3 *Accident site*

❖ TESTIMONIES OF PARTICIPANTS

For technical examination of the traffic accident, the following circumstances from individual explanations are important.

- CAGIVA DRIVER

During an interrogation he, besides other things, stated that he was riding on his Cagiva motorcycle, then he started to overtake a vehicle. After that he only caught sight of something coming to him from the left, afterwards he only could recall himself lying on the ground. While overtaking the Skoda vehicle, he was driving faster than *50 km/h*, he estimated his speed to *65 km/h.* After overtaking the Skoda vehicle he was in the middle of the road.

Fig. 4 *Damage on Cagiva*

Fig. 5 *Damage on Honda*

- **HONDA DRIVER**

He stated that he was severely injured especially on his head, he could not remember anything related to the accident, he remembered about it in the hospital.

- **SKODA VEHICLE DRIVER**

In an explanation for the Police he, besides other things, stated that he was driving approximately by speed of *30 to 40 km/h* and that a green motorcycle caught up with him. Furthermore, he stated that he kept observing what might the motorcyclist do, but he overtook him with an approximate speed of *50 to 60 km/h*. After overtaking the motorcyclist, he got to distance of approximately *50 metres* in front of his vehicle and kept driving in the middle of the road. When he was approximately at the level of the local pub entrance he noticed that, in the opposite direction, there was another motorcycle also driving in the middle of the road. After that motorcycles collided, in his opinion, both motorcycles were riding in the middle of the road and he could not guess, whether any of them was driving in the opposite direction.

- **WITNESS**

In an explanation for the police he, besides other things, stated that he was standing near back entrance of the local pub and he noticed that a rider of a red motorcycle (Honda) arrived and stopped approximately *30 m* far from the pub and read local notice board. In a while he went on the road. Honda motorcycle rider put the motorcycle in second gear approximately to *50 km/h* and, after that, he collided with the rider of the oncoming Cagiva motorcycle riding approximately *70 km/h*.

❖ **INVESTIGATIVE EXPERIMENT**

Police performed an investigative experiment with the participation of the Skoda vehicle driver and the witness. Experiment´s purpose was to authenticate positions of individual objects during the accident according to explanations of participants and witnesses. Next, the site was geodetically measured and also both drivers´ range of vision was verified.

❖ **INJURIES OF MOTORCYCLISTS**

Expert evaluated the state of both injured drivers involved in the accident and stated that injuries of both motorcyclists were caused by a mechanism of dense force (violence) of great intensity. This mechanism could have been an impact of the front side of head and the left lower limb into solid subject, or intense impact to solid ground.

3 ESTIMATION OF THE POINT OF COLLISION

Point of collision is determined by end of the mark left by the Cagiva motorcycle, both as longitudinally and transversely and it may be proclaimed that the point of collision of both motorcycles corresponds with PPC – evidence no. 9 in the Plan.

3.1 CALCULATION OF MOVEMENT SEQUENCES OF MOTORCYCLES

In this part, a mathematical calculation of movement sequences of motorcycles is illustrated.

❖ CALCULATION OF THE CAGIVA MOTORCYCLE MOVEMENT SPEED AFTER COLLISION

Movement of the Cagiva motorcycle since collision to its final position may be divided, according to the photo documentation and the plan of the accident site, to falling movement phase of the motorcycle (*3,4 metre*), motorcycle sliding on asphalt surface (*4 metres*) and, in the end to phase, when the motorcycle back part was sliding on a grassy surface outside the roadway (*1 metre*). Motorcycle was in its final position situated from the point of collision at distance of *8,4 m* in total.

From the documented marks left by the Cagiva motorcycle on the roadway it may be assumed that from collision to final position it was travelling equally decelerated movement with average deceleration, which lies, for the movement of the motorcycle on the grass, according to literature [4] page 499 within the range of *5 to 6 m.s*$^{-2}$, for sliding of the motorcycle on the asphalt the deceleration may be expressed by means of multiple of skid friction coefficient between dry asphalt and metal (*0,36 to 0,45*) and gravitational acceleration or *4 m.s*$^{-2}$ according to literature [9], page 239. Average deceleration of the motorcycle during its movement from collision to final position thus it may be considered within the range of *3,5 to 4,5 m.s*$^{-2}$. Speed of the Cagiva motorcycle just after collision thereafter equals:

$$v_{1C} = \sqrt{2 \cdot a_{1C} \cdot s_{1C}} = 7{,}7 \text{ až } 8{,}7 \; m.s^{-1} = 27{,}7 \text{ to } 31{,}3 \; km.h^{-1} \qquad (1)$$

where:

a_{1C} *=3,5 až 4,5 m.s*$^{-2}$ ..... average deceleration during movement of motorcycle from collision to final position, see above,

s_{1C} *=8,4 m* ..... distance, which the motorcycle travelled from collision to final position, see the plan of the accident site.

From the above mentioned is thus the total time of movement of the motorcycle from the collision to place, where its rear part left asphalt surface is equal to:

$$t_{1C} = \frac{v_{1C}}{a_{1C}} = 1{,}7 \text{ to } 2{,}5 \; s \qquad (2)$$

Minimum time of the motorcycle falling, on which no additional forces had effect may be, according to literature [4] page 499, expressed from relation:

$$t_p = \sqrt{\frac{2 \cdot \alpha^2 \left(i^2 + h^2{}_T \right)}{g \cdot \left(h_T - h' \right)}} = 0{,}6 \; s \qquad (3)$$

where:

α*'= 1,4 rad* ..... difference of vertical angle of lying and standing motorcycle,

i = 0,2 m ..... radius of inertia to longitudinal axis,

h_T *= 0,55 m* ..... height of COG of standing motorcycle,

h' *= 0,15 m* ..... height of COG at fall,

g = 9,81 m.s^{-2} ..... gravitational acceleration.

Considering the fact that during the collision the motorcycle was affected by dynamical forces especially force of the oncoming motorcycle, which caused its faster fall, it may be assumed that time of its real fall was shorter, which may be proved by subsequent control.

If the motorcycle was moving during the fall at a constant speed, it would had travelled at minimum necessary time of falling of *0,6 s* distance from *4,6 to 5,2 m.* Considering the documented frictional marks it is obvious that the motorcycle was falling at distance of *3,4 m* that, at given post collision speed, it corresponds with time of falling within the range of *0,35 to 0,4 s.*

Total time of the Cagiva motorcycle movement since the collision to final position is thus *1,7 to 2,5 s*, of which at least *0,35 s* the motorcycle was falling. Just after the collision the Cagiva motorcycle was moving at speed within the range of *27 to 31 km.h*$^{-1}$.

❖ CALCULATION OF SPEED AND TIME OF MOVEMENT OF THE HONDA MOTORCYCLE AFTER COLLISION

The last phase of the Honda motorcycle movement was falling on its side and sliding on the roadway from the point of collision to the final position at distance of *3 m*. From the documented marks left by the Honda motorcycle on the roadway it may be assumed that on this 3 metre long section it was travelling by equally decelerated movement with deceleration, which is corresponding to multiple of below mentioned range of coefficient of skid friction and gravitational acceleration.

$$v_{1H} = \sqrt{2 \cdot s_{1H} \cdot g \cdot f} = 4{,}6 \text{ to } 5{,}1\, m.s^{-1} = 16{,}6 \text{ to } 18{,}4\, km.h^{-1} \qquad (4)$$

where:

s_{1H} *= 3 m* ..... distance, which the motorcycle covered since collision to final position,

f =0,36 až 0,45 ..... coefficient of skid friction between dry asphalt and metal, or rubber, see literature [4] page 355,

g = 9,81 m.s-2..... gravitational acceleration.

Period of time of the motorcycle movement since collision to final position thus equals to:

$$t_{1H} = \frac{v_{1H}}{f \cdot g} = 1 \text{ to } 1{,}4 \text{ s} \qquad (5)$$

Total time of the Honda motorcycle movement since collision to its final position is thus *1 to 1,4 s*, of which at least *0,35 s* the motorcycle was falling. Just after collision the motorcycle was moving at speed ranging from *16,6 to 18,4 km.h*$^{-1}$.

❖ ESTIMATION OF EQUIVALENT ENERGY SPEED OF MOTORCYCLES

For calculation of the collision speed of both motorcycles, it is necessary to define so called equivalent energy speed - EES, ie. speed corresponding to energy, which was destroyed during origin permanent deformations on motorcycles during collision. The Honda motorcycle was damaged on its front part by an impact to left front part of the Cagiva motorcycle. The Honda motorcycle, by impact became damaged on the front wheel rim and shift of front fork. The Cagiva motorcycle came damaged on front mask and headlight and left front part in area of engine cover, crampons and gearshift lever.

The measurement of the damaged Honda motorcycle resulted in that the wheelbase was shortened approximately about *0,18 metre*. For estimation of range of EES may be considered shortening of the wheelbase within technically acceptable range from *0,17 to 0,21 m*. After shortenings are recorded in the chart in **Fig. 6**, which was compiled from results of crash tests in Germany, it may be concluded that technically acceptable range of EES lies between *39 and 43 km/h* (also compared to [11]).

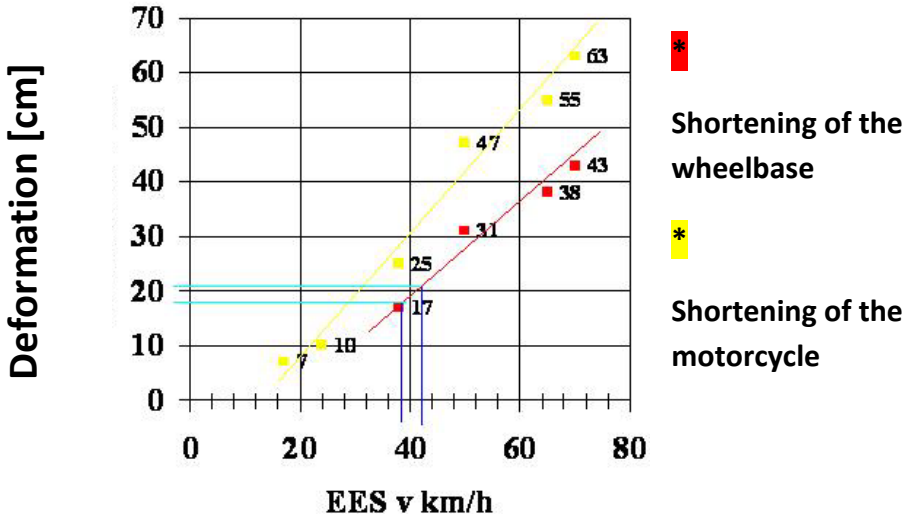

Fig. 6 *Estimation of EES (Honda) from shortening the wheelbase, according to literature [10]*

Technically acceptable point of collision of motorcycles corresponding to their mutual damage is in **Fig. 7.**

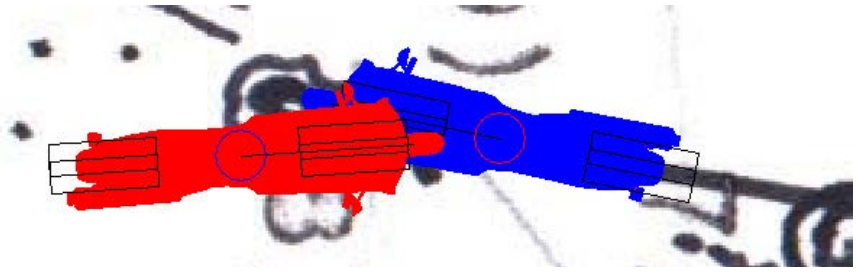

Fig. 7 *Technically acceptable point of collision of motorcycles including motorcycles positions (Honda left, Cagiva right)*

Knowing the EES of the Honda motorcycle (EES_H) the EES of the Cagiva motorcycle may be roughly calculated by means of the following relation:

$$EES_C = EES_H \cdot \sqrt{\frac{m_{oH}}{m_{oC}}} = 11{,}63 \text{ to } 12{,}83 \text{ m.s}^{-1} = 42 \text{ to } 46 \text{ km.h}^{-1} \qquad (6)$$

where:

EES_H *=10,83 to 11,94 m.s*$^{-1}$ ..... EES of the Honda, discovered from its damage post collision,

m_{oH} *= 290 kg* ..... actual weight of the Honda motorcycle,

m_{oC} *= 251 kg* ..... actual weight of the Cagiva motorcycle,

❖ COLLISION SPEEDS OF MOTORCYCLES

From the plan and explanations may be concluded, where the Honda motorcycle could start up.

From the setting in motion distance and knowledge of middle acceleration of the motorcycle the collision speed of the Honda motorcycle may be concluded:

$$v_{2H} = \sqrt{2 \cdot a_{2H} \cdot s_{2H}} = 11{,}1 \text{ to } 12{,}2 \text{ m.s}^{-1} = 40{,}0 \text{ to } 43{,}9 \text{ km.h}^{-1} \qquad (7)$$

where:

a_{2H} *= 2,5 to 3 m.s*$^{-2}$ ..... middle acceleration of motorcycle with volume of 600 ccm during setting in motion, see literature [9] pages 196 to 197,

s_{2H} *= 24,5 m* ..... distance, which motorcycle travelled from setting in motion to point of collision according to the plan of the accident site.

Collision speed of the Cagiva motorcycle may be then determined from energy balance of motorcycles movement prior and post collision, see literature [4]. Total energies prior and post collision must equal to:

$$E_{kH} + E_{kC} = E'_{kH} + E'_{kC} + E_{dH} + E_{dC} \quad (8)$$

where:

$E_{kH} = \frac{1}{2} \cdot m_{oH} \cdot v_{2H}^{\ 2}$ ..... kinetic energy of translation of the Honda motorcycle prior to collision using actual motorcycle weight (m_{oH}),

$E_{kC} = \frac{1}{2} \cdot m_{oC} \cdot v_{2C}^{\ 2}$ ..... kinetic energy of translation of the Cagiva motorcycle prior to collision using actual motorcycle weight (m_{oC}),

$E'_{kH} = \frac{1}{2} \cdot m_{oH} \cdot v_{1H}^{\ 2}$ ..... kinetic energy of translation of the Honda motorcycle post collision,

$E'_{kC} = \frac{1}{2} \cdot m_{oC} \cdot v_{1C}^{\ 2}$ ..... kinetic energy of translation of the Cagiva motorcycle post collision,

$E_{dH} = \frac{1}{2} \cdot m_{oH} \cdot EES_{H}^{\ 2}$ ..... energy needed for origin of deformations on the Honda motorcycle

$E_{dC} = \frac{1}{2} \cdot m_{oC} \cdot EES_{C}^{\ 2}$ ..... energy needed for origin of deformations of the Cagiva motorcycle

After adaptation for the Cagiva motorcycle speed prior to collision we get:

$$v_{2C} = \sqrt{\frac{m_{oH} \cdot v_{1H}^{\ 2} + m_{oC} \cdot v_{1C}^{\ 2} + m_{oH} \cdot EES_{H}^{\ 2} + m_{oC} \cdot EES_{C}^{\ 2} - m_{oH} \cdot v_{2H}^{\ 2}}{m_{oC}}} \quad (9)$$

$$v_{2C} = 14{,}7 \ to \ 16{,}2 \ m/s \ = 53{,}0 \ to \ 58{,}0 \ km/h$$

where:

m_{oH} *= 290 kg* ..... actual weight of the Honda motorcycle,

m_{oC} *= 251 kg* ..... actual weight of the Cagiva motorcycle,

EES_H *= 10,8 to 11,9 m.s*$^{-1}$ ..... equivalent energy speed of the Honda motorcycle,

EES_C *= 11,6 to 12,8 m.s*$^{-1}$ ..... equivalent energy speed of the Cagiva motorcycle,

v_{1H} *= 4,5 to 5,1 m.s*$^{-1}$ ..... post collision speed of the Honda motorcycle,

v_{1C} *= 7,7 to 8,7 m.s*$^{-1}$ ..... post collision speed of the Cagiva motorcycle,

v_{2H} *= 11,1 to 12,2 m.s*$^{-1}$ ..... speed of the Honda motorcycle prior to collision.

The Cagiva motorcycle was travelling at the moment of collision at speed ranging from *53 to 58 km/h.*

❖ SPEED OF THE CAGIVA MOTORCYCLE AT THE BEGINNING OF LEFT MARKS

From the plan and documentation of the accident site it is obvious that the Cagiva motorcycle was braking intensively prior to collision, which is confirmed by the measured left mark. After measurement from the plan of the accident site it may be stated that this mark is *3,9 metre* long.

Speed at the beginning of leaving the braking mark may be then determined:

$$v_{3C} = \sqrt{{v_{2C}}^2 + 2 \cdot a_{3C} \cdot s_{3C}} = 16{,}5 \, to \, 18{,}0 \; m.s^{-1} = 59{,}5 \;\; to \;\; 65{,}0 \; km.h^{-1} \qquad (10)$$

where:

v_{2C} *= 14,7 to 16,2 m.s*$^{-1}$ ..... collision speed of the Cagiva motorcycle,

a_{3C} *= 7 to 8 m.s*$^{-2}$ ..... motorcycle deceleration during leaving the braking marks, see literature [9], pages 163 to 187,

s_{3C} *= 3,9 m* ..... length of mark left by motorcycle from the beginning of the braking to the point of collision, see the Plan of the accident.

❖ SPEED OF THE CAGIVA MOTORCYCLE AT THE BEGINNING OF BEGINNING OF BRAKING INCLINATION

Speed at the beginning of braking inclination then may be determined:

$$v_{4C} = v_{3C} + \frac{a_{3C}}{2} \cdot t_n = 18{,}6 \, to \, 20{,}4 \; m.s^{-1} = 67{,}0 \;\; to \, 73{,}4 \; km.h^{-1} \qquad (11)$$

where:

v_{3C} *= 16,5 to 18,0 m.s*$^{-1}$ ..... speed of the Cagiva motorcycle at the beginning of leaving the braking marks,

a_{3C} *= 7 to 8 m.s*$^{-2}$ ..... motorcycle deceleration while leaving braking marks, see literature [9], pgs 163 to 187,

t_n *= 0,6 s* ..... time of braking inclination, see literature [9], pg. 184.

❖ ANALYSIS OF THE MOTORCYCLE COLLISION BY MEANS OF THE IMPULZ EXPERT PROGRAM

There was also an analysis of both motorcycles collision prepared by means of expert program for calculation of collisions. Analysis of the collision works on discovered facts from the accident site, technical data of the motorcycles, further from collision positions of both motorcycles, their damage, post-collision speeds and motorcycles´ movements directions after collision. The aim of the calculation of collision by means of the Impulz Expert, Czech made program is to find such collision impulse that corresponds with fulfilled conditions of all entered input values, see [6], [8]. Such impulse then directs from the collision point to intersection of areas, which corresponds with given conditions.

Solution by means of the Impulz Expert program complies with calculation solution of motorcycles speeds and equivalent energy speeds. Earlier calculated speeds of motorcycles were hereby verified.

❖ MOTORCYCLISTS´ MOVEMENT SIMULATION

By means of the PC Crash simulating program ([6] and [7]) motorcyclists´ movement instantly post collision was being solved. On the following figure, there is motorcyclists´ movement noticeably in compliance with situation at the accident site and injuries of both motorcyclists with their heads and left lower limbs collision.

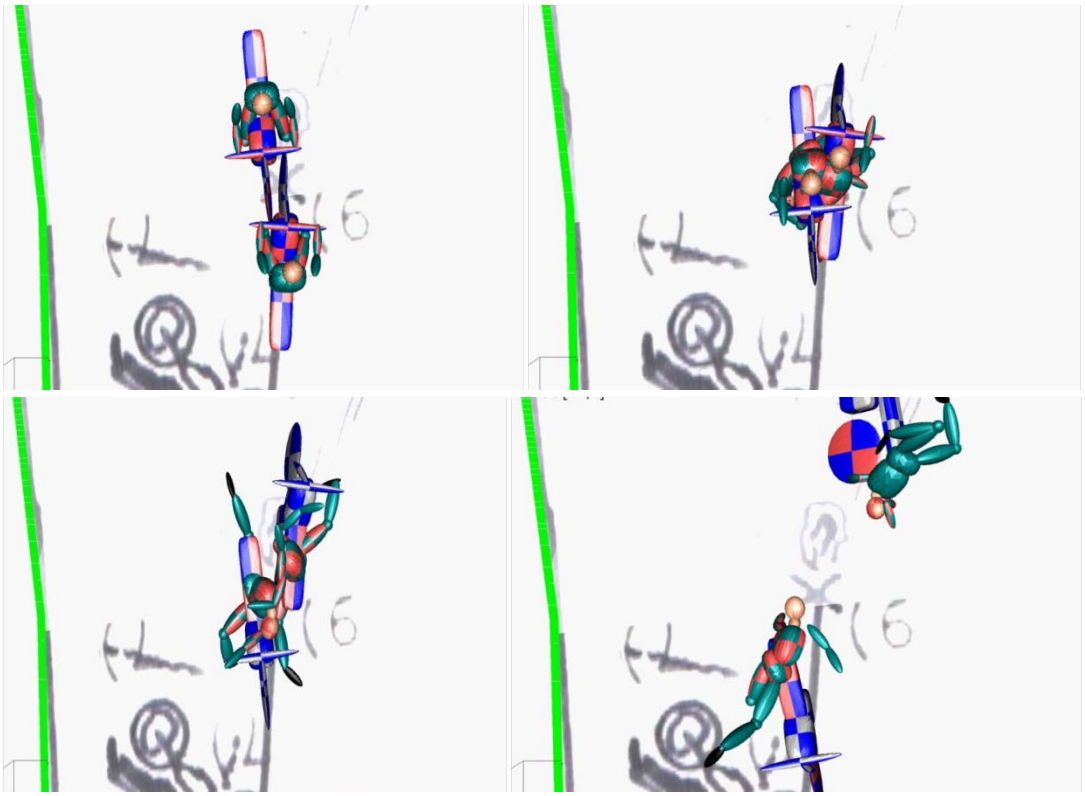

Fig. 8 *Sequence of multibody system model motion (0,00 to 0,30 s post collision) - simulated in PC-Crash*

❖ CALCULATION OF THE CAGIVA MOTORCYCLE SPEED WHILE OVERTAKING THE SKODA VEHICLE

At the beginning of overtaking was the Cagiva motorcycle travelling at a speed of ca. *60 km/h*, the Skoda vehicle at a speed of ca. *43 km/h*. While overtaking the Skoda vehicle, the Cagiva motorcycle rider at time of *5,1 s* prior to collision accelerated to *64 km/h*, *54 metres* ahead of the point of collision he got in front of the Skoda vehicle, he kept riding in opposite direction lane and from the speed of *67 km/h* also reacted *34 metres* ahead of the point of collision and *1,9 s* prior to collision to the oncoming Honda motorcycle. During reaction time his speed was changing only by influence of the roadway gradient, during beginning of breaking effect his speed decelerated to *62 km/h* and during braking while leaving marks it was able to decelerate to collision speed of *57 km/h*.

At time of *3,8 s* prior to collision and distance of *25 m* ahead of the point of collision the Honda motorcycle started up. At time of *3 s* prior to collision and at distance of *22 m* ahead of the point of collision the Honda motorcycle was situated at the intersection boundary and it was entering the main road. In this instant the Cagiva motorcycle was situated *54 m* from the point of collision at the level of the front part of the Skoda vehicle and the Honda motorcycle rider, considering view possibilities, could not see him. In the instant, when the Cagiva motorcycle rider started to react to the Honda motorcycle, the Honda motorcycle was situated *17 m* ahead of the point of collision and accelerated up to collision speed of *42 km/h*. According to explanations and absence of any prior to collision marks of the Honda motorcycle, it may be concluded that the Honda motorcycle rider did not react in any way to newly-emerged situation.

Considering the Honda rider view, in the instant of moving off he had a view over the main road *20 metres* over point of collision. He was able to catch sight of the oncoming motorcycle *2 s* prior to collision, when he was situated *37 m* ahead of the point of collision. He did not react by an intense breaking to oncoming motorcycle, because he probably counted on that he would make it back to his own traffic lane.

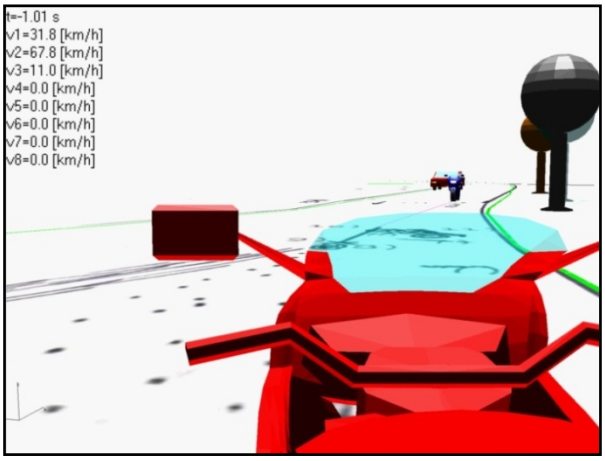

Fig. 9 *View from Honda towards Cagiva and collision point (1 sec prior collision) [7]*

3.2 POSSIBILITIES OF AVOIDING THE ACCIDENT TO HAPPEN BY ACCIDENT PARTICIPANTS

From the calculations and simulation of prior-to-collision movement of vehicles it may be concluded that from the technical view it was possible to prevent the accident from happening so that the Cagiva motorcycle rider, after overtaking the Skoda vehicle, would return back to his lane in time and would not keep riding in opposite direction lane. If the Cagiva motorcycle driver had been traveling at speed of *50* km/h prior to collision, he would have not been able to overtake the Skoda vehicle and the collision would had never happened.

From the calculations and simulation it may be concluded that the Honda motorcycle driver had the chance to prevent the accident to happen as far as he was riding his motorcycle by the right edge of the road and not close to the middle of the road. It is a question of other than technical evaluation, whether he was supposed to ride that way.

After considering all available materials it may be concluded that from the technical view cause of the particular accident was the fact that the Cagiva motorcycle rider after overtaking the Skoda vehicle did not return back to his traffic lane and that he kept riding in the opposite direction lane, where he collided with the oncoming Honda motorcycle driver head-on. This fact is best indicated by the beginning of the blocking marks left by the Cagiva motorcycle was situated *2,4 metres* from the left edge of the road in his direction of riding, thus *0,6 metre* over the middle of the road. Movement prior to braking was such that the rider with his motorcycle after overtaking was riding back to his traffic lane and he was not able to finish this manoeuvre.

3.3 CONTRADICTIONS IN PREVIOUS EXPERTS´ OPINIONS

In this case there were made 4 experts´ reports (in the field of traffic). Concerning the speeds, experts reached approximately the same results i.e. collision speed of Cagiva about *60* km/h, collision speed of Honda *from 40 to 50* km/h. However, one of the opinions stated as a technical cause of the accident the movement of the Honda motorcycle, which was riding in his traffic lane, but not by the right edge of the road.

4 CONCLUSION

Nowadays, a major concern all over the world is the traffic problem; this problem came from the fact that the population, number of vehicles and economic activities are increasing significantly. This problem has been considered as the biggest problem facing countries all around the world, including the developed and developing ones, due to the fact that traffic accidents cause vast damages to the economy and community. The vehicle traffic accidents between Canada, Czech Republic and Korea have been studied in this paper. A solution of a real traffic accident which happened in the Czech Republic between two motorcycles is presented as well in this paper.

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